TECHNICAL BULLETIN
No. 1

RECENT DEVELOPMENTS
IN
DWELLING CONSTRUCTION

Revised January 1, 1937

FEDERAL HOUSING ADMINISTRATION
WASHINGTON, D. C.

FHA Form No. 2212
(Rev. 1-1-37)

U. S. GOVERNMENT PRINTING OFFICE: 1936

RECENT DEVELOPMENTS IN DWELLING CONSTRUCTION

Part I

GENERAL SURVEY

The subject of prefabricated houses is one of the foremost in popular discussion today. Innumerable articles appear in the periodicals and newspapers and questions about prefabricated construction continue to pour into this Administration. It would appear that an impression is being made in the public mind that the problem of building better houses at a lower cost, and with great ease and rapidity, has been solved or is about to be solved by the prefabricated house and that the mass production of such houses is a new industry with all the possibilities of, for example, the automobile industry.

It is true that, during the period of inactivity which for the past 5 or 6 years has encompassed the construction industry, the industry itself has not been asleep. The period has been characterized by a wide interest in the technical problems arising from the design and construction of houses. This interest has taken its impetus from a recognition of the fact that new dwellings have in the past been built only for a very limited class. It also has developed from a realization that, if a mass market for homes is to be developed, lower-priced homes must be built either through careful planning and a simplification of the required accommodations, or through economies effected by mass production which will permit the construction of housing at prices within the reach of a greater proportion of the people.

The apparent success of the automobile, radio, and other industries in creating a product capable of broad mass consumption has inspired the experimenters in housing to attempt to produce in their field a product capable of similar broad use. The effort has followed many directions; from endeavors to introduce greater efficiency in customary trade operations to attempts to revolutionize both methods and materials.

Recognizing that a marked lowering of dwelling costs or a radical change in accepted materials and design would have an influence upon the level of value of existing property and upon the rate of obsolescence of existing dwellings, the Technical Division of the Federal Housing Administration has undertaken to accumulate information concerning new developments in dwelling construction. It maintains a file on new methods of construction and welcomes data on new developments in this particular field. With a view to keeping this information as up to date and complete as possible, where practicable, its engineers have conducted personal inspections. In its work it has received assistance from the National Bureau of Standards and the Bureau of Foreign and Domestic Commerce, both of the Department of Commerce; the Forest Products Laboratory, of the Department of Agriculture; the Tennessee Valley Authority; Albert

Farwell Bemis; the Pierce Foundation; the Portland Cement Association; and others who have been making studies along these lines, which assistance it wishes gratefully to acknowledge.

This report presents the following:

1. The approach which is being made to the problem of better construction at lowered costs, and an evaluation of the work which has been done, together with tentative conclusions as to its probable effect on the dwelling market.

2. Brief descriptions of the different materials and methods of construction which are being tried out, together with lists of the individuals and concerns who have been engaged in such work. This includes some methods developed and used in Europe.

While every effort has been made to make this report comprehensive, the widespread experimentation now taking place, together with the secrecy with which it is frequently characterized, makes any assurances on this score impossible. The same reservations must be made for any conclusions drawn from the data, since there is no way to gage either the rate at which developments may proceed or the degree of popular acceptance that may be gained for them. Although the opinions stated are based upon the best engineering judgment that may be applied to the situation as it stands at present, no permanent quality can be claimed for them. Subsequent reports may present opinions of a contrary nature.

THE NEW APPROACH

For centuries houses have been built of wood, brick, stone, mortar, and plaster. The wood, brick, and stone have been brought to the site of the building operation in comparatively small sizes and there cut and trimmed by hand to fit the requirements of the particular building and then put together piece by piece—studding, beams, sheathing, siding, bricks, lath, and plaster—usually by hand. The newer mechanical work has followed a similar procedure.

This has necessitated the employment at the site of a large amount of hand labor, much of it skilled and highly specialized. For the specialist the amount of work on a single job is limited. To avoid having idle men on the pay roll, the employment period has been the hour or day, men being laid off as soon as their services are not needed. This has resulted in a large amount of idle and unpaid-for time and, to compensate for this, an hourly or daily wage, high in proportion to that paid in other lines of work.

The attack on the problem of building better and more cheaply is being made on four fronts: purchasing materials and equipment in larger quantities from fewer sources; factory fabrication of larger units and units combining more than one purpose so as to lessen the work of assembly and erection on the job site; the use of materials supposedly better suited to their function and to factory fabrication; and employment of labor by the week instead of by the hour with a lower hourly wage in return for steadier employment. It is with the development of factory fabrication and with the materials and methods of assembly used in such fabrication that this report is concerned.

FACTORY FABRICATION OR READY-TO-ERECT CONSTRUCTION

To take advantage of the spread between wholesale and retail prices, a new middleman is appearing in the field. This new middleman is really a manufacturer of houses. He employs architects and engineers to design his houses, to study available materials and work out new methods of assembling them. He contracts in advance, usually directly, with manufacturers for his anticipated material and equipment requirements, based on his decisions to use certain materials and equipment in certain ways to produce a definite product. He then offers for sale, not his services as do architects and contractors, not a piece of property consisting of house and land as do operative builders, but a house more or less complete and with varying degrees of standardization, which in a sense is a trade-marked product, and which is ready to erect on land owned by the purchaser. Erection may be handled by the manufacturer through local representatives, perhaps using their own erection crews, with local subcontractors for foundations and mechanical work, or the purchaser may make his own arrangements for erection.

Only a few concerns have adopted the practice of marketing a complete housing assembly. Many new types of structural enclosures and new methods of building them, however, have been prepared for commercial production.

The phrase "ready-to-erect" is used to define the practice of ordering by plan a structural enclosure or a complete house, with delivery made by one concern of all parts ready to fit into their proper places without the usual cutting and trimming. In this report, ready-to-erect construction has been considered as either Complete Housing Assemblies, which include heating, plumbing, and electrical wiring and equipment, or Structural Enclosures, in which the mechanical equipment and materials, and sometimes the interior finish, is supplied by the purchaser.

The factory fabricated house—or as it is often called, the prefabricated house—is a misnomer. Our transportation facilities do not provide for the economical delivery, from factory to site, of a completed house.

In the usually accepted meaning of the words, the structure of the prefabricated house is made in the factory in large panels, which are assembled and fastened into place on the site without the usual hand work of cutting, fitting, and fastening together a number of pieces of wood, laying brick on brick, and mixing and spreading mortar and plaster.

The purposes of prefabrication are to transfer to the factory as much as possible of the work of putting together a house, to reduce the time needed for its erection, and so through the greater efficiencies of mass factory production to utilize power and machines, concentrated planning and purchasing, and the reduction of waste, to effect economies which will reduce the cost of construction. To what extent this aim has been attained and what may be expected from the development of this new technique in building construction, it is the purpose of this article to examine.

With the exception of adobe and rammed-earth construction, all conventional construction methods in common use involve factory fabricated units. Widely distributed at the present time are factory fabricated closets, stairways, mantels, kitchens, plumbing and heat-

ing assemblies, and framed and hung doors and windows. In addition every brick, nail, and piece of lumber is basically a factory-made unit.

The new technique merely calls for a considerable increase in the size of the various factory-made building units with a subsequent reduction in numbers of units required. The new technique further expects that, by size standardization of building units and interchangeability, greatly reduced erection time will result. There are numerous schools of thought, utilizing the new technique whose unit sizes may run from the usual wall-high panel of varying widths to the entire side of a house, or in some cases to an entire room.

Part II

PROSPECTS FOR PREFABRICATION

A study of the many new methods of construction and assembly, and of the materials used in them, leads the Technical Division to the following conclusions:

The present is still largely a period of experiment. Urged on by the desire to be ready to meet the anticipated demand for new homes, manufacturers are steadily putting out new forms of materials and new methods of using them. These are still in the exploratory stage. Experience records in their use are rather limited so that it may be too early to tell which have definite merit and will result in the hoped-for better construction and lowered costs.

The newer techniques in building construction have not generally resulted in lowered costs, and an immediate lowering of cost in all cases is not to be anticipated. Comparative cost studies made between quoted prices for ready-to-erect houses and houses built in the usual way, equivalent in size, plan, durability, fire resistivity, insulation, and quality of finish and equipment, show few cases where the ready-to-erect construction has resulted in a saving in total cost. In many cases such construction has been more costly and, compared with wood frame construction, it has usually been appreciably more expensive.

The problem of economical distribution over considerable distances of large specialized building sections is one of the greatest problems facing the prefabricator today, and it is quite conceivable that radical changes must take place in our transportation system before this situation can be met in such manner that ready-to-erect construction costs at the site will be comparable or competitive with conventional methods unless fabricating plants are more widely distributed.

It is conceivable that a considerable increase in prefabrication of small, easily transported building sections and building units may result, with a gradual evolution toward complete prefabrication. Present indications are that all of the factors being equal, the distribution problem is the most critical now facing the prefabricator.

The generally higher cost limits sales to those few who are attracted to this type of construction, and who do not know or do not mind that the cost may be higher.

There are many obstacles in the way of obtaining the mass production on which most of these methods base their hopes for lowered costs. The immediate demand is small, and it is difficult to gage the coming

market. This limits volume of manufacture, and the planning of production is very difficult.

In this country the public has been slow to favor the modern international style of architecture frequently used in the newer construction. The materials and large panels of this construction lend themselves readily to this style of architecture, and designers have favored it, believing that the public will accept it. Stimulated by the example of the recent Chicago Century of Progress, people have become interested in modern design, and it seems reasonable to believe that it will gradually obtain the widespread favor which it has obtained in Europe. The complaint against standardization is unfounded, as evidenced by examples of skilled treatment, and fairly pointless when the dreary monotony of some low-priced subdivisions is considered. Still this feeling may tend to defer widespread public acceptance. The question of modern architectural design has been treated at greater length in Technical Bulletin No. 2, entitled "Modern Design."

Since, in its ultimate development, the assembly of all the parts of the factory-fabricated house above the foundations could be handled by a few skilled mechanics, it is evident that craft distinctions now existing in the building trades would be broken down and that many of the men now engaged in building construction would have to look to the factories for employment. The labor organizations in the building trades are fighting hard to prevent the introduction of methods which will reduce the amount of job labor. This attitude is in many ways retarding the introduction of factory-fabricated units.

Urban localities have varying and often injustifiably rigid building codes. In many places building codes and building officials are slow to recognize new materials and methods of construction. The introduction of any revolutionary development in building construction often must await considerable code revision.

Thus faced with a fourfold handicap of high cost, unfamiliar appearance, labor opposition, and unfavorable building codes, the widespread adoption of considerable changes in our methods of constructing dwellings is not to be immediately anticipated. Such obstacles, however, may not be insurmountable, and the apparently ample capital available for experiment and the increasing ingenuity being displayed by inventors leave little doubt that the effort to overcome them will be vigorously pursued.

Factory production does eliminate the disturbing effects of weather and to a great extent the influence of seasonality. Furthermore, the long period of construction inactivity has left us with a sadly depleted supply of skilled mechanics and we are even now confronted with a problem of finding sufficient workmen, trained in the specialized work required on conventional construction built entirely in the field, piece by piece. This combination of circumstances together with economies possible through factory production may constitute a pronounced encouragement to prefabrication.

The handicap of cost is the most critical. If a method were devised which would result in the construction of houses at appreciably lower cost than at present, public acceptance would doubtless be forthcoming in spite of the tendency to cling to the familiar, and the resistance due to craft practice and building codes would gradually be broken down. While, as has been said, this prospect does not

seem to be immediate, the advantages of rapid erection, flexibility, convenience, comfort, and low maintenance which several of the new systems seem to offer, will probably, in the meantime, create a slowly expanding market.

In considering the possible reductions in costs which might be obtained through the development of ready-to-erect construction, the following figures showing the approximate distribution of costs will be helpful. The selling price of the average new home is made up of the cost of land, its improvements, and the utilities which serve the building, the construction costs of the building, financing and selling expenses, and profits. Of this total, the construction cost of the building is about 70 percent, divided in to 50 percent for the structure and its finishes and 20 percent for equipment and accessories. Only about 25 percent of the total selling price goes to direct labor on the job.

The reduction in cost to be anticipated from the use of factory-fabricated methods must largely be found in savings in the labor of erecting the structural enclosure. This saving, together with additional economies, which may be made through efficient and concentrated management and purchase of materials, may reduce the total selling price in the neighborhood of 15 percent. Such savings would, however, at the present stage of development, seem to be offset by unfamiliarity of labor and managment with this type of construction, the higher cost of the materials used, the tendency to increase equipment and accessories, and the distribution of overhead expenses over a very limited production. Progress in the prefabrication field over the past year has indicated that much greater effort is being expended in the development of low-cost homes, with less attention directed to the inclusion of unnecessary mechanical equipment and not so much stress placed upon fire-safe features, which in many cases actually did not exist.

In the present inconclusive stage of development, only a few months time may make a considerable difference in the prospect. The situation is, therefore, one which merits close and continued attention.

Part III

RULINGS

New methods of construction are investigated by the Technical Division to determine whether houses so constructed will be acceptable for mortgage insurance insofar as the method of construction is concerned, and rulings on such methods are issued by the Technical Division for the guidance of our local insuring offices and for the information of the buying and building public.

Rulings on materials as such are not made except in a case where the material has a definite structural function—such structural materials are considered principally from the standpoint of appropriate use.

No rulings on any new method of construction will be issued by the Technical Division unless one complete structure involving the new method shall have been erected and subjected to normal weathering and occupancy for a test period. Such a structure provides a practical demonstration of its structural soundness and also provides

answers to the many problems of fabrication and erection coincident with new methods.

Proponents of new methods of construction who have erected a structure should advise the Technical Division of the Federal Housing Administration, Washington, D. C., as to its location and when it is available for inspection. In addition, the Technical Division should be furnished with a complete written description, specifications, technical data, laboratory test records, experience records, and a complete set of detail drawings showing the essential features of the construction. These drawings should include at least one isometric assembly drawing disclosing full details of the construction from the footings to the roof, including wall openings, inside and outside corners, also bearing and non-bearing partitions.

Proponents of new methods of construction, still in the design stage, are invited to present their system to the Technical Division for study and constructive criticism. By so doing the system may be more rapidly projected to the practical erected product suitable for study in regard to a ruling.

Favorable rulings are not to be considered as an approval or endorsement by the Government or its agent, the Federal Housing Administration. They consist of a brief description of the essentials of the method and a decision as to the acceptability of such method for purposes of mortgage insurance, with such limitations as it is deemed advisable to impose. *Rulings are issued for a period of 6 months and upon application may be renewed or revised to include modifications developed by experience and advanced knowledge.* Data on new methods will be reviewed periodically for this purpose so as to maintain their value current as a guide to the insuring offices.

These rulings cover the method of construction only and do not mean that any building so constructed is acceptable per se. In order to qualify for an insured mortgage many factors other than method of construction must be considered, and each individual property is judged on its own merits.

Copies of rulings issued by the Technical Division on methods of construction may be obtained by applying to the Federal Housing Administration, Washington, D. C.

NOTE.—Advances in mechanical equipment such as plumbing, heating, and air conditioning and related construction such as insulation and windows, and the question of their cost of operation and maintenance, have not been discussed here.

Part IV

MATERIALS AND METHODS OF CONSTRUCTION

STEEL AND OTHER METALS

Light structural shapes for use in dwellings and other low buildings where great strength is not required are being developed and put on the market by the manufacturers of structural steel.

Built-up framing members such as bar joists have been in use for some time for floor construction. Similar members have been brought out for walls and roof rafters.

Strip steel framing members of around 12 gage to 16 gage are increasing in use. These are light in weight, easy to handle, and are often designed to accept nailing, either with standard or with special

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nails. Framing members are interconnected, either with bolts or by welding.

Strip steel frames used in wall construction are made by welding together in the shop, framing and bracing members to form rectangular sections which, when bolted together on the job, act as a complete wall frame.

Framing of tubular steel members, which has been tried in Europe, is beginning to receive some attention in this country. This type of construction has been in common use here for scaffolding.

In frameless steel construction, panels are shop fabricated of a series of cells or of large sheets with the vertical edges bent inwardly, usually called pans.

Cellular panels have been used for some time for subfloors usually laid over structural steel framing in large buildings. These have now been adapted for bearing wall construction and for floors, so that no framing is required. Panels of sizes to fit any plans may be made by welding the cells together in the shop.

The pans—or plates with the edges bent inwardly—are usually so made and fastened together as to form structural units for bearing walls. They are sometimes used for sloping roofs or as forms for reinforced concrete floors.

In frameless steel construction, the steel is sometimes used as the exterior or interior surface, finished except for painting; or any desired material may be used over the steel, such as brick, stucco, or plaster on lath, etc.

In all methods of lightweight steel construction the elimination of condensation is a very vital factor. Only by its elimination on interior and concealed steel surfaces can the resistance to corrosion of the metal sections of the house be sufficient to be practical for sound, permanent construction.

Sheets of various metals such as steel, copper, zinc, and aluminum are used for exterior and interior surfaces. These are secured to steel or wood framing.

Steel must be painted to protect it against corrosion. Protection as well as decoration is sometimes obtained by porcelain enamel or baked enamel on the steel plates.

Metal walls and roof should be backed with insulating materials to retard heat conductance. It is advisable that an air space be maintained between the metal and insulation.

A large number of houses have been built in Europe with steel pans and with steel frames and sheets. The sheets and pans have usually been of heavier gages than used here.

A good many houses have been built using structural and strip steel frames. Only those which depart in some way from ordinary framing methods have been listed here.

STEEL AND OTHER METALS

Name of concern	Description of construction offered
American Houses, Inc., 480 Lexington Ave., New York City.	Steel frame of specially shaped studs and trussed floor joists. Exterior walls between studs are panels of insulating material covered both sides with asbestos cement. Subfloors and partitions are of gypsum plank. This concern markets and erects a complete housing assembly and has built over 40 houses.
Berger Manufacturing Co., Division of Republic Steel Corporation, Canton, Ohio.	Rectangular strip steel wall frame units of 16-gage channels and bracing welded together, and strip steel channel floor joists. 2 houses built near Washington, D. C.
Bethlehem Steel Co., Bethlehem, Pa.	Electrically welded steel frame built up from open work expanded steel studs and joists. A complete structural frame available for various designs. About 20 houses erected.
George F. Boes, 604 South 28th St., Lafayette, Ind.	Wall high panel units formed from sheet steel attached to wooden framing. Units contain fill insulation and are provided with a plaster base at the shop. 10 houses erected.
Columbian Steel Tank Co., 1401 West 12th St., Kansas City, Mo.	Structural enclosure with 18-gage galvanized steel pan walls, strip steel frames for partitions, and floors and roof of ordinary wood frame construction.
Copper Houses, Inc. 10 East 40th St., New York City.	Strip steel framing fabricated into units to which are shop welded steel bound panels of fiber insulation sheathed with copper. 16 houses erected.
Corkanstele, 270 Madison Ave., New York City.	Structural enclosure with a structural steel frame covered on the exterior with an insulating sheathing of cork slabs; subflooring of a precast slab of concrete with a cork aggregate and partitions of the same material. A number of such houses have been built.
Estate Homes, Inc., 700 North Wabash Ave., Chicago, Ill.	Lightweight structural steel frame of standard shapes. Hung, floating zinc sheathing attached to frame by clips. I-pan formed steel floors and roofs. A complete housing assembly.
Ferrocon Corporation, Queen St. and Mermaid Lane, Chestnut Hill Station, Philadelphia, Pa.	Boxlike wall, floor, and roof units formed from strip steel and hyrib metal lath. Adjacent units lock together forming structural framing by means of formed steel keys. Various exterior and interior finishes possible, but stucco and plaster intended as standard. Not a complete housing assembly. 2 houses have been built.
General Houses, Inc., 620 North Michigan Ave., Chicago, Ill.	System No. 1.—Structural enclosure with 14-gage steel pan walls, carrying load and acting as exterior finish. Steel floor and roof joists. A complete housing assembly. About a dozen houses built.

STEEL AND OTHER METALS—Continued

Name of concern	Description of construction offered
General Houses, Inc., 620 North Michigan Ave., Chicago, Ill.	System No. 2.—Steel frame of formed steel studs and formed steel roof joists. Wall panels consist of wood frame covered outside with asbestos board and inside with plywood. Aluminum foil inside the panels acts as insulation. Roof panels consist of wood frame covered top and bottom with plywood and insulated by two sheets of aluminum foil suspended within the frame.
Harnischfeger Corporation, Milwaukee, Wis.	Shop fabricated units for walls, floors, and roof built up from welded steel frames, bolted together. Walls surfaced outside with Homasote fiberboard, inside with gypsum board, floors, and roof optional materials. About 50 houses erected.
Insulated Steel Construction Co., Crawford St., Middletown, Ohio.	Structural enclosure of panels made of 19-gage rectangular steel cells. Steel may or may not be left exposed as wall surface. About 25 houses built by this method.
W. C. Lea, Inc., Los Angeles, Calif.	Bolted skeleton framework of galvanized 16 gage formed strip steel sections for walls, floors, and roof. Webs are punched for passage of pipes and conduit; flanges of studs have lanced teeth for attachment of finish. 20 to 30 houses erected.
Erwin M. Lurie, 208 South LaSalle St., Chicago, Ill.	Structural enclosure having a structural steel frame; inner and outer wall surfaces formed with furring channels and metal lath to receive stucco and plaster; metal lath and plaster ceilings, ribbed lath and concrete subfloors.
Martin-Parry Corporation, York, Pa.	Structural frame of strip steel members which slide together and are secured by clips, eliminating bolts. Interior finish secured by special mouldings.
McKay Engineering Co., Builders Exchange Building, Cleveland, Ohio.	A standard structural steel frame enclosed within double walls of any standard materials. Attached by special clips.
National Houses, Inc., 60 East 42d St., New York City.	Structural enclosure of 14-gage steel pan walls; steel frame partitions, steel joists for floors and trusses for roof.
Palmer Steel Buildings, Inc., Los Angeles, Calif.	Sales and engineering service for structural enclosure of Robertson Keystone cellular steel panels. 1 or 2 such houses built in Los Angeles.
Reynolds Corporation, 19 Rector St., New York City.	Manufacturers of metal lumber framing members, such as studs, joists, plates, sills, etc., all formed of galvanized strip steel in hollow shapes filled with gypsum cement composition to hold nails. A precast gypsum composition floor slab is also produced for use in connection with this metal lumber. About 35 houses have been constructed.

STEEL AND OTHER METALS—Continued

Name of concern	Description of construction offered
H. H. Robertson Co., Grant Bldg., Pittsburgh, Pa.	Panels of keystone shaped steel cells which can be used for wall and floor construction. In use for subflooring for some years.
Rostone, Inc., 308 Main St., Lafayette, Ind.	System No. 1—Unit system consisting of standard size slabs of synthetic stone carried on steel tracks held in place with dowels. Tracks are bolted to steel or wood frames. About 150 buildings erected.
	System No. 2—Unit system built up of light weight synthetic stone blocks.
Soulé Steel Co., 1750 Army St., San Francisco, Calif.	Rectangular steel wall frame units of pressed steel studs welded to transverse steel members. Trussed steel floor joists.
Steel Housing Corporation, 228 North La Salle Street, Chicago, Ill.	Structural enclosure with walls of strip steel I-shaped studs supporting 2 layers of 2 inches thick Thermax separated by a 1 inch air space; partitions 3 inches Thermax supported by star shaped studs; floors and roof of 16 gage steel T pan construction.
Steel Buildings, Inc., Crawford St., Middletown, Ohio.	Walls and sloping roof of 20-gage galvanized steel interlocking pans. Materials for a complete housing assembly furnished by this source. Associated with the American Rolling Mills Co.
Stran-Steel Corporation, 6100 McGraw Ave., Detroit, Mich.	Strip steel framing members, usually channels, with webs crimped and spaced slightly apart to receive nails.
C. L. Van Ness, Akron, Ohio.	Tubular steel wall columns and 14-gage strip steel channel floor joists. Inner and outer walls, floors, and ceilings of 20-gage steel pans. Hollow wall and floor construction used for air ducts and as radiating surface.
Variplan, Inc., Transportation Bldg., Cincinnati, Ohio.	A complete housing assembly using a steel frame and steel sheets for exterior finish.

WOOD

In spite of its cheapness and ease of handling, the advantages of wood for more complete factory fabrication would not seem to have been realized.

Ready-cut wood frame houses have been on the market for a number of years. These are usually ordered from a catalog or plan and the seller ships all the wood (and in some cases other materials also), with each individual piece cut to length and size. While a large number of such houses have been built, their market has been mainly in rural localities and small towns and villages where the immediate supply of building materials and labor is small.

Factory fabricated panels have been largely used for portable buildings. These generally follow the usual wood framing methods. Various modifications of this idea are coming into use for factory fabricated houses.

In Sweden, the city of Stockholm, in its housing development, uses large factory fabricated panels, one and two stories high, consisting of 2-inch-thick tongue and groove planking, wood-chip insulation, sheathing paper, and siding, the panels being made up complete with windows and doors.

While large sheets made of pressed wood pulp, fiber, or of plywood are finding increasing use as interior finishes, the new technique has, until quite recently, generally neglected the use of wood. Now, with the development of thermosetting artificial resin glue and hot presses especially adapted to its use, plywood and other laminated wood construction can be made more durable and weather resistant.

Structural units made of plywood glued to opposite sides of a wood frame develop much greater strength than nailed-up panels having the same size members. Such construction utilizes the "stressed covering" principle used in aeroplane construction and permits of much lighter construction. Such units in large panels are used for the structural enclosures of buildings, forming either in connection with steel framing or without other framing, the walls, floors, and roof with the plywood acting as interior and exterior finished surfaces if desired. Insulation is usually included within the units.

Structural units may also be formed of plywood panels and strip steel channels, the flanges of the channels being restrained in grooves in the edges of the plywood.

The objection raised against wood is that, unless treated, it is combustible, subject to attacks by rot and termites, and it shrinks and warps. Much work is being done today in the field of wood preservation to overcome these objectionable features, but the durability of such treatments and of the synthetic resin glues remains to be proven.

Name of concern	Description of construction offered
Agasote Millboard Co., Trenton, N. J.	Locally fabricated wall and partition units lag-screwed together, built up of wood framing surfaced both sides with Homasote fibre board nailed and glued on. Floor and roof construction is of conventional wood framing. 20 houses erected.
Asbestos Buildings, Inc., Philadelphia, Pa.	Panel units joined by splines involving a wooden frame faced both sides with asbestos cement board. 16 houses erected.
Aladdin Co., Bay City, Mich. Louis Bossert & Sons, Inc., Grand St. and Newton Creek, Brooklyn, N. Y. Bennett Homes & Lumber Co., Inc., North Tonawanda, N. Y. International Mill & Timber Co. (Sterling System Homes), Bay City, Mich. Lewis Manufacturing Co., 23d and Michigan Ave., Bay City, Mich. National Mill & Lumber Co., 400 High St., Oakland, Calif. Pacific System Homes, 5800 South Boyle Ave., Los Angeles, Calif. Sears, Roebuck & Co., Chicago, Ill. Tumwater Lumber Mill Co., Olympia, Wash.	Ordinary wood frame construction of the ready-cut type.
Dally Construction & Engineering Co., Lloyd Bldg., Seattle, Wash.	Structural enclosure of glued-up plywood structural units joined by splines. Light roof trusses of wood using timber connectors.
Forest Products Laboratory, U. S. Department of Commerce, Madison, Wis.	Structural enclosure of glued-up plywood structural units, joined by splines.
Gunnison Magic Homes, New Albany, Ind.	Structural enclosure consisting of panels of wood frame covered both sides with plywood glued on and filled with insulating material. Panels are bolted together and form walls, partitions, floor, ceiling, and roof. Interior surfaces are finished with selected hardwood veneer. 14 houses erected.
Haskelite Mfg. Corporation, 208 West Washington St., Chicago, Ill.	Structural enclosure of plywood. Inner and outer walls, floors, and ceilings held together and stiffened by 18-gage strip-steel channels and I's whose flanges fit into grooves in the edges of the plywood sheets.
Hodgson Co., Boston, Mass.	Structural enclosure of panels made of wood frames covered with a wood-finishing material on one side and insulation board on the other. Additional insulation and waterproof paper may be included in the panel. A large number of such houses built over a considerable period of years.

Name of concern	Description of construction offered
Klicka Lumber Co., San Diego, Calif.	Wall construction of 2- by 4-inch milled studs 12 inch o. c. grooved to receive 1- by 12-inch plank forming interior finish. Exterior is covered by beveled lap siding over building paper. 78 houses erected.
Newark Manufacturing Co., Newark, Ohio.	Structural enclosure of panels, wedge-bolted together, made of wood framing covered on the outside with plywood and inside with gypsum board. Exterior finish may be shingles or siding. Panels insulated with glass wool. 5 or 6 houses erected.
Prefabricated Construction, Inc., Lloyd Building, Seattle, Wash.	A house formed from wall high glued up plywood units joined by splines and finished conventionally. 8 houses erected.
Santa Ana Lumber Company, Santa Ana, Calif.	A wall construction made up of milled wooden studs which receive two pine plank, one forming the interior, the other the exterior. 60 houses erected.

CONCRETE

Many systems have been developed using precast concrete units, usually reinforced. They may be divided into certain general classes as follows:

Systems using bearing units laid up as a masonry wall—usually without reinforcing.

Systems using small thin slab units—up to a few feet long or high secured to steel, or poured in place or attached to precast concrete studs. Similar construction is used for floors.

Systems using large thin reinforced panels—a story high and any width—sometimes an entire wall. Similar construction for floors.

In the two latter systems, flanges are often cast on the units, and these sometimes serve as a form for poured in place concrete studs or columns, or act as studs or joists themselves.

Other systems use stucco or concrete applied to metal lath secured to a steel frame or reinforcing members, or to poured in place concrete studs or columns, beams, and joists.

The Portland Cement Association's Report on Survey of Concrete House Construction Systems contains extensive lists and descriptions of concrete systems.

Name of concern	Description of construction offered
The Broughton Co., 1427 Chestnut Ave., Kansas City, Mo.	System consists of a combination of precast wall panels, joists, and studs. About 70 houses built.
Carrol Tri-Ply Co., 180 North Michigan Ave., Chicago, Ill.	Entire exterior walls cast in 1 piece. Stone slab exterior finish imbedded in cast wall, joints pointed, floors and roofs of reinforced concrete. Several hundred houses built.
Concrete Housing Corp., New York, N. Y.	Precast reinforced concrete panels 3 feet wide and story height with flanged and grooved edges. A number of houses erected.
Crowe House Construction Co., Burlingame, Calif.	Cast concrete wall panels with integral steel framing. Cast concrete joists for floor and roof construction.
Dextone Co., New Haven, Conn.	Precast slabs resting on precast joists.
John J. Earley, 2131 G St. NW., Washington, D. C.	Large precast wall slabs fastened to poured-in-place studs. The concrete is made from colored aggregates with the aggregates exposed on the outside surface as a decorative finish. 2 houses built near Washington, D. C.
Goldsmith Metal Lath Co., Cincinnati, Ohio.	Panels of metal lath secured to metal pans which act as forms for poured-in-place columns, beams, and floor joists and slabs. Stucco and plaster is applied to the metal lath.
Haco Construction, Harry Cole, 4954 West Pine Blvd., St. Louis, Mo.	Small precast slabs with steel channel flanges cast in the slabs, welded to steel framework.
Insulrock, John F. Downing, 150 Hughes Ave., Buffalo, N. Y.	Precast slabs for inner and outer walls and ceilings used as plaster and stucco base and secured to precast studs and joists.
Makeco, Matthews & Kenan, Smith-Young Tower, San Antonio, Tex.	Double-bearing walls of large thin slabs tied together.
Arthur H. Olmsted, Rye, N. Y.	Precast studs around which concrete exterior wall is poured and to which interior finish is fastened.
Swan Houses, Inc., Bell Building, Chicago, Ill.	Precast reinforced concrete wall panels, studs, and joists. Several houses erected.
Texas Concrete Construction Co., Houston, Tex.	Moore unit system built up of precast reinforced channel-shaped wall and floor units 1 foot wide, various lengths. Over 50 houses built.
Quentin Twachtmen, Connecticut Precast Buildings Corporation, Irvington, N. Y.	Precast hollow units of light weight concrete in large sections to form walls, floors, partitions, and roof, with interior surfaces finished ready for decoration. 1 house built at Greenwich, Conn., several in New Jersey.

GYPSUM AND OTHER PLASTICS

Precast gypsum units have been made which are generally similar to concrete units. Gypsum, however, when used in an exterior wall or roof must be covered with a waterproof finish of other material.

Gypsum is also cast into thin sheets or boards for wall finishes and as a backing for plaster.

Boards or slabs made of insulating material coated with plastics of various kinds, such as asbestos cement, are used for curtain walls, the plastic acting as interior and exterior finish.

Thin sheets of synthetic resinous materials are used for wall finishes.

REINFORCED BRICK

Steel reinforcing rods are used in the brick joints to increase strength and make possible the use of thinner walls.

One system uses precast brick panels one brick thick, made on the site by laying the brick and reinforcing rods in a form laid horizontally on the ground and pouring mortar in the joints.

In another the brick are laid up in the wall with reinforcing rods in the joints. Reinforced brick columns, beams, and curtain walls are thus formed.

Name of concern	Description of construction offered
Holsman & Holsman, 140 South Dearborn St., Chicago, Ill.	Reinforced brick walls made of precast panels.
Judson Vogdes, 334 South 19th St., Philadelphia, Pa.	Reinforced brick columns, beams, and curtain walls.

FOREIGN PRACTICE

Great Britain

Thorncliffe Iron Works, Newton Chambers & Co. System, Sheffield.	Exterior of cast-iron plates, combined with a wood frame.
G. & J. Weir, Ltd., Glasgow.	Steel sheet on wood frame. A great many of these built.
Atholl Steel Houses, Ltd.,	3/16-inch steel plates with angle and T frames. About 650 such houses built.
Braithwaite & Co., Telford System, West Bromwich.	1/8-inch steel plates on wood frame.
Doorman, Long & Co., Middleborough.	Gunite on wire mesh and steel frame.

FOREIGN PRACTICE—Continued

France

Name of concern	Description of construction offered
Forges et Ateliers de Commentry-Oissel, Paris.	Cellular concrete blocks combined with steel frame.
Société des Forges de Strasbourg, Paris.	Units of corrugated steel sheets on steel frame.
Société de Construction Multicellulaires, Paris.	Panels of cellulose, asbestos, and silica on corrugated steel box sections, filled with sawdust insulation with interior panels of sawdust and binder.
Société de Constructions Metallique Fillod, Paris.	Story high steel pans with steel tubing, frame, and sawdust insulation.
M. M. Mopin,	Exterior walls of precast reinforced concrete panels secured to steel frame.

Germany

Heinrich Blecken, Duisburg,	¼-inch steel pans and steel framing. Over 700 houses built.
United Upper Silesian Iron Works Co.	Steel sheets on steel frame.
Hirsch, Kupfer & Messingwerke, Finow, Hamburg.	Copper sheets on wood frame.

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